

**THEREFORE WHAT IS CLAIMED IS:**

1. An apparatus for spraying powders, comprising:
  - a) a housing having first and second opposed ends, the housing defining a chamber terminating in an outlet passageway at said first end of the housing;
  - b) a high voltage electrode positioned in the chamber spaced upstream of the outlet passageway;
  - c) a ground electrode positioned in the chamber spaced upstream from the high voltage electrode, the ground electrode having a surface area sufficiently larger than a surface area of the high voltage electrode in order to allow high voltages to be applied to the high voltage electrode without arch discharging occurring in the chamber; and
  - d) an inlet opening into the chamber for conducting a powder-gas mixture into the chamber.
2. The apparatus according to claim 1 including means for supplying a cleaning gas toward the high voltage electrode to reduce powder deposits on the high voltage electrode.
3. The apparatus according to claim 2 wherein the inlet for conducting a powder-gas mixture into the chamber is located at the second end of the housing.

4. The apparatus according to claim 3 wherein the high voltage electrode includes at least one charging pin connected to a conductor located in an electrically insulated tube disposed along an axis of the housing, the conductor being connectable to a power supply for applying high voltages to the at least one charging pin.
5. The apparatus according to claim 4 wherein the chamber defines an inner cylindrical surface and the ground electrode is a cylindrical electrode having an outer diameter such that the cylindrical electrode is substantially concentric with the inner cylindrical surface, the cylindrical electrode having an inner surface which has the surface area that is sufficiently larger than the surface area of the high voltage electrode.
6. The apparatus according to claim 5 wherein the means for supplying a cleaning gas to reduce powder deposits on the high voltage electrode includes the electrically insulated tube.
7. The apparatus according to claim 4 wherein the chamber defines an inner cylindrical surface and the ground electrode includes a plurality of sections of a cylindrical electrode mounted around the inner cylindrical surface with each section being separately or jointly grounded, the sections of the cylindrical electrode having inner surfaces which cumulatively have the surface area that is sufficiently larger than the surface area of the high voltage electrode.

8. The apparatus according to claim 5 wherein a first section of the chamber upstream of the high voltage electrode containing the ground electrode has a cross sectional area which is less than that of a second section of the housing containing the high voltage electrode in order to increase a velocity of the powder-gas mixture flow within the first section and to create turbulence in order to keep the ground electrode from being coated by powder.

9. The apparatus according to claim 5 wherein a first section of the chamber upstream of the high voltage electrode containing the ground electrode includes an insulated cylindrical member disposed symmetrically along the axis of the housing for narrowing the chamber in the first section in order to increase a velocity of the powder-gas flow and to create turbulence in order to keep the ground electrode from being coated by powder.

10. The apparatus according to claim 9 wherein the housing has a portion surrounding the insulated cylindrical member disposed symmetrically along the axis which has a radius which is larger than a radius of a portion of the housing surrounding the high voltage electrode.

11. The apparatus according to claim 9 wherein said insulated cylindrical member disposed symmetrically along the axis of the housing has a downstream end portion, and wherein the ground electrode includes an electrical conductor mounted on the downstream end portion so that electrical field lines are

developed between the high voltage electrode and both the cylindrical electrode and the electrical conductor.

12. The apparatus according to claim 4 including an insulated cylindrical member disposed symmetrically along the axis of the housing having a downstream end portion spaced upstream of the high voltage electrode, and wherein the ground electrode includes an electrical conductor mounted on the downstream end portion of insulated cylindrical member so that electrical field lines are developed between the high voltage electrode and the electrical conductor.

13. The apparatus according to claim 4 including an electrically insulated cylinder having a diameter greater than an outer diameter of said electrically insulated tube and less than the inner diameter of a section of the chamber adjacent to the second end of the housing and symmetrically aligned with the axis, the electrically insulating cylinder having one end located at the second end of the housing and an opposing end positioned a distance downstream of a downstream end portion of the ground electrode, and wherein the inlet opening for conducting a powder-gas mixture into the chamber located at the second end of the housing is an annular region defined by the one end of the electrically insulated cylinder and the insulated tube.

14. The apparatus according to claim 13 wherein the chamber defines an inner cylindrical surface and the ground electrode includes a cylindrical electrode having an outer diameter such that the cylindrical electrode is substantially concentric with the inner cylindrical surface, the cylindrical electrode having an inner surface which has the surface area that is sufficiently larger than the surface area of the high voltage electrode, and wherein the cylindrical electrode has an inner diameter greater than the diameter of the electrically insulated cylinder.

15. The apparatus according to claim 14 wherein the means for supplying a cleaning gas toward the high voltage electrode includes means for injecting the cleaning gas into the electrically insulated tube.

16. The apparatus according to claim 14 including means for supplying additional cleaning gas into an annular region located between the one end of the electrically insulated cylinder and the second end of the housing to prevent buildup of powder on the ground electrode.

17. The apparatus according to claim 13 wherein the ground electrode is a generally cylindrical electrode mounted on an outer surface of the electrically insulating cylinder, the generally cylindrical electrode having an outer surface which has the surface area that is sufficiently larger than the surface area of the high voltage electrode.

18. The apparatus according to claim 17 wherein the means for supplying a cleaning gas toward the high voltage electrode includes means for injecting the cleaning gas into the electrically insulated tube.
19. The apparatus according to claim 17 including means for supplying additional cleaning gas into an annular region located between the one end of the electrically insulated cylinder and the second end of the housing to prevent buildup of powder on the ground electrode.
20. The apparatus according to claim 2 wherein the inlet opening for conducting a powder-gas mixture into the chamber is located at a position in the housing located between the ground electrode and the high voltage electrode whereby the powder-gas mixture is introduced into the chamber downstream of the ground electrode and whereby powder particles acquire a charge as they move downstream toward the high voltage electrode to be ejected from the chamber through the outlet passageway.
21. The apparatus according to claim 20 wherein the chamber defines an inner cylindrical surface and the ground electrode includes a cylindrical electrode having an outer diameter such that the cylindrical electrode is substantially concentric with the inner cylindrical surface, the cylindrical electrode having an inner surface which has the surface area that is sufficiently larger than the surface area of the high voltage electrode.

22. The apparatus according to claim 21 wherein the second end of the housing includes a gas inlet for flowing gas through the cylindrical ground electrode for avoiding powder deposit buildup on the cylindrical ground electrode.
23. The apparatus according to claim 22 wherein the housing has a generally cylindrical shape and has a cylindrical axis, and wherein the high voltage electrode includes at least one charging pin connected to a conductor located in an electrically insulated tube disposed along an axis of the housing, the conductor being connectable to a power supply for applying high voltages to the at least one charging pin.
24. The apparatus according to claim 23 wherein the means for supplying a cleaning gas toward the high voltage electrode includes a gas passageway in the electrically insulated tube.
25. The apparatus according to claim 23 wherein the inlet opening for conducting the powder-gas mixture into the chamber includes a conduit attached to the housing at an angle greater than 90 degrees with respect to the outlet passageway so that powder is directed into the chamber in a downstream direction away from the ground electrode.
26. The apparatus according to claim 20 including an insulated cylindrical member disposed symmetrically along an axis of the housing between the

second end of the housing and the inlet for conducting a powder-gas mixture into the chamber, the insulated elongate cylindrical member having a downstream end portion spaced upstream of the high voltage electrode, and wherein the ground electrode includes an electrical conductor mounted on the downstream end portion of the insulated cylindrical member so that electrical field lines are developed between the high voltage electrode and the electrical conductor.

27. The apparatus according to claim 26 wherein the second end of the housing includes a gas inlet for flowing gas adjacent the cylindrical ground electrode for avoiding powder deposit buildup on the cylindrical ground electrode.

28. The apparatus according to claim 27 wherein the housing has a generally cylindrical shape, and wherein the high voltage electrode includes at least one charging pin connected to a conductor located in an electrically insulated tube disposed along the axis of the housing, the conductor being connectable to a power supply for applying high voltages to the at least one charging pin.

29. The apparatus according to claim 28 wherein the means for supplying a cleaning gas toward the high voltage electrode includes a gas passageway into the electrically insulated tube.

30. The apparatus according to claim 28 wherein the inlet opening for conducting the powder-gas mixture into the chamber includes a conduit attached



to the housing at an angle greater than 90 degrees with respect to the outlet passageway so that the powder-gas mixture is directed into the chamber in a downstream direction away from the ground electrode.

31. An apparatus for spraying powders, comprising:

a) a housing having first and second opposed ends and a housing wall defining a chamber terminating in an outlet passageway at the first end of the housing;

b) a high voltage electrode mounted in the chamber spaced upstream of the outlet passageway;

c) a ground electrode mounted in the chamber spaced upstream from the high voltage electrode, the ground electrode having a surface area sufficiently larger than a surface area of the high voltage electrode in order to allow high voltages to be applied to the high voltage electrode without arc discharging occurring in the chamber; and

d) an inlet opening into the chamber at a position in the housing wall located downstream from the ground electrode and upstream of the high voltage electrode for conducting a mixture of gas and powder particles into the chamber where the powder particles acquire a charge as they move downstream toward the high voltage electrode to be ejected from the chamber through the outlet passageway.

32. The apparatus according to claim 31 including means for supplying a cleaning gas toward the high voltage electrode to reduce powder deposits on the high voltage electrode.
33. The apparatus according to claim 32 wherein the housing has a generally cylindrical shape and a cylindrical axis, and wherein the high voltage electrode includes at least one charging pin connected to a conductor located in an electrically insulated tube disposed along the cylindrical axis of the housing.
34. The apparatus according to claim 33 wherein the inlet opening for conducting the mixture of gas and powder particles into the chamber includes a conduit attached to the housing at an angle greater than 90 degrees with respect to the cylindrical axis at the outlet passageway so that powder particles are directed into the chamber in a downstream direction away from the ground electrode.
35. The apparatus according to claim 34 wherein the second end of the housing includes a gas inlet for flowing an additional cleaning gas through the chamber for avoiding powder deposit buildup on the ground electrode.
36. The apparatus according to claim 35 wherein the chamber defines an inner cylindrical surface and the ground electrode is a cylindrical ground electrode having an outer diameter such that the cylindrical ground electrode is

substantially concentric with the inner cylindrical surface, the cylindrical ground electrode having an inner surface which has the surface area that is sufficiently larger than the surface area of the high voltage electrode.

37. The apparatus according to claim 36 wherein the gas inlet in the second end of the housing directs the additional cleaning gas through the cylindrical ground electrode for avoiding powder deposit buildup on the cylindrical ground electrode.

38. The apparatus according to claim 37 wherein a portion of the housing upstream of the inlet opening into the chamber for conducting the mixture of gas and powder particles into the chamber includes a cylindrical member disposed symmetrically along the cylindrical axis of the housing for narrowing an effective cross sectional area of the chamber in the portion of the housing upstream of the inlet opening into the chamber in order to increase a velocity of cleaning gas flowing into the air inlet and flowing downstream to the outlet passageway.

39. The apparatus according to claim 38 wherein the cylindrical member terminates at a first end spaced upstream of the inlet opening into the chamber for conducting the mixture of gas and powder particles into the chamber, and wherein the ground electrode is located on the first end of the cylindrical member.

40. The apparatus according to claim 34 wherein the chamber has a cross section, and wherein the ground electrode has a planar surface disposed in the chamber so as to be perpendicular to the cylindrical axis and whereby the ground electrode occupies a substantial area of the cross section, the planar surface having the surface area that is sufficiently larger than the surface area of the high voltage electrode.

41. The apparatus according to claim 40 wherein the chamber is a generally cylindrical chamber having a circular cross section, and wherein the ground electrode is a circular disk-shaped electrode.

42. The apparatus according to claim 40 including an additional gas inlet located in the wall of the housing in close proximity to, but downstream of, the ground electrode for flowing additional cleaning gas into the chamber adjacent to the planar surface of the ground electrode for avoiding powder deposit buildup on the ground electrode.

43. The apparatus according to claim 13 wherein the chamber defines an inner cylindrical surface and the ground electrode includes a plurality of sections of a cylindrical electrode mounted around the inner cylindrical surface with each elongate section being separately or jointly grounded, the sections of the cylindrical electrode having inner surfaces which cumulatively have the surface area that is sufficiently larger than the surface area of the high voltage electrode.

44. The apparatus according to claim 20 wherein the chamber defines an inner cylindrical surface and the ground electrode includes a plurality of elongate sections of a cylindrical electrode mounted around the inner cylindrical surface with each elongate section being separately or jointly grounded, the sections of the cylindrical electrodes having inner surface which cumulatively have said surface area that is sufficiently larger than the surface area of the high voltage electrode.

45. The apparatus according to claim 5 wherein the high voltage electrode includes at least one charging pin mounted on the inner cylindrical surface spaced upstream from the outlet passageway.

46. The apparatus according to claim 13 wherein the high voltage electrode includes at least one charging pin mounted on the inner cylindrical surface spaced upstream from the outlet passageway.

47. The apparatus according to claim 20 wherein the high voltage electrode includes at least one charging pin mounted on the inner cylindrical surface spaced upstream from the outlet passageway.